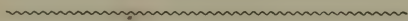


Colour in spirit, evidently somewhat faded. The body is surrounded by alternating dusky and light rings with very irregular crooked margins. Head above dusky olivaceous with pale spots in the middle of most of the shields; upper labials and anterior lower labials pale with dusky margins. An imperfect pale collar behind the head: all the lower part of the head and neck whitish. There are 30 pale rings on the body, the first pale ring imperfect above, and the dark patch in front not continuous across the throat, the rest of the rings encircle the animal. Farther back the pale rings become grey with pale margins and light spots occur in the dark rings. On the belly, throughout the anterior part of the body, the dark rings are only about half as broad as the white, above the difference is less, and near the head the dark rings are much broader above than the white. There are 16 rings on the tail.

This snake is distinguished from all other species of *Ophites* by having 19 instead of 17 rows of scales round the body. It approaches nearest to *O. septentrionalis**, the precise habitat of which is unknown, but is probably the Himalayas or Assam, the type specimen having been collected by Dr. Jerdon soon before his departure from India, and found unlabelled amongst his collections after his death. From *O. septentrionalis* the present species appears to be distinguished by more numerous scales, by its differently shaped anterior frontals, and by the dark rings extending across the belly.

A single specimen was procured by Mr. Gammie at the Cinchona plantation in South-eastern Sikkim. This specimen measures $31\frac{1}{2}$ inches, of which the tail is 7. It is rather surprising to find a new snake in so well explored a locality.



VIII.—*Notes on the Earthquake in the Punjab of March 2nd, 1878.*—

By A. B. WYNNE, F. G. S.

(Read 5th June.)

Earthquakes in the Punjab are not uncommon, but little effort seems to have been made to record their occurrence in any way that might prove useful; indeed as a rule they are neither sufficiently frequent nor pronounced to leave more than a passing impression, though the directions from which the undulations come are occasionally noticeable, and doubtless, with proper appliances, they would form an interesting study.

On the 2nd of last March the most severe shock which has occurred within the memory of the present generation, so far as I can learn, affected the whole of the northern part of the province. With regard to it I have collected a few notes which I offer more as a record of the event than as

* Günther, P. Z. S., 1875, p. 233.

an exhaustive or abstrusely scientific treatment of the subject. Accurate details concerning so large an area are not within the reach of every one to collect, and I have had a little difficulty in learning even so much as I have put together. Some of this information has been derived from personal observation, some from the accounts given by friends or acquaintances, and some from the reports in the "Pioneer" newspaper, and "Civil and Military Gazette."

It may be as well to give the localities from which information has been received in the form of a list, with the hour of the shock, where known, reduced to Madras time,* and the duration of the earth-movement, opposite.

Punjab Earthquake of March 2nd, 1878.

Locality.	Hour felt, (Madras time).†	Duration.	Sound wave.	Authority.
Bannu,	Uncertain,	Uncertain..	None ..	R. Udny, Esq., Deputy Commissioner.
{ Kohát, ..	About noon,	About 2 minutes.	No information.	Major Swinton Browne, 6th P. I.
{ Kohát, ..	Noon, Madras (11·37 Station.)	Uncertain..	Rumbling sound.	Major Ross, 1st Sikhs per Capt. Plowden, C. S.
Pesháwar, ..	About noon,	Over a minute.	Noticed ..	Capt. M. S. Wynne, 81st Regiment.
Naoshera, ..	No details, ....	....	....	Reported.
Hoti Mardán,	No details, ....	....	....	Major Stewart—Guides.
Attock,	About noon,	Over a minute.	Unnoticed..	Capt. C. F. Massy, C. S.
Abbottabad,	Noon,	1 minute, 50 seconds.	Unnoticed..	Personal.
Ráwalpindi,	Immediately after noon.	Over a minute.	No sound ..	Dr. Henderson, Col. Surgeon.
....	....	....	Sound noticed	Mr. P.—
Jhelum,	Noon,	Uncertain..	No sound ..	Buchanan Scott, Esq., R. E.
Murree,	Noon,	$\frac{1}{2}$ a minute to 3 minutes.	Unrecorded	Rev. Mr. Corbyn, Mr. W. L. Holman.
Lahore,	11·56 A. M.,	3 minutes ..	....	"Civil and Military Gazette" Mar. 4th, 1878.
Lahore,	About noon? ..	Unrecorded	....	"Pioneer" Mar. 6th, ,,
Lahore,	12-50 P. M. ?	Unrecorded	....	R. Dick, Esq.
Ferozpúr, ..	Unrecorded,	5 minutes ..	Noticed, loud	Ditto.
Simla,	12 h. 1 m. ? ..	9 minutes ..	Unrecorded	Ditto.
Masurí,	Unrecorded,	No information.	No information.	"Pioneer" Mar. 1878.

* Where the time of the place is unknown to be that of Madras, or the reduction thus rendered doubtful, a note of interrogation is inserted.

† Madras time according to Frontier authorities is 23 minutes faster than the local time kept, by which Station guns are fired.

A few days before the greater shock, I felt an earthquake at Abbottabad, on February 26th, at 8:40 P. M. It was of the kind usual in these parts, lasted only a few seconds and did no damage. A sharp shock was reported in the "Pioneer" to have occurred at Kángra on the 19th of March (after the greater one), and others occurred in Hazára—on March 29th at 7 P. M.; on April 4th at 6:11 A. M., (a short and sharp one); on April 19th at 5:9 A. M., a more considerable one; on April 21st at 9:20* A. M., lasting about five seconds. That of April 19th was, though short, rather severe yet insufficient to bring down tall chimneys at Abbottabad badly shaken and bulged by the earthquake of March 2nd. The shock of the 21st caused the roof beams of the dák bungalow at Haripur to creak, while on the night of the same day there was a slight shock after midnight at Ráwalpindi.

In all the cases just mentioned except the Kángra one, of which I have no information in point, and that of April 4th, the undulation was more or less clearly felt to be from west to east, as seems to be the case most frequently in the N. W. Punjab, but on April 4th, it appeared to come from north to south. In none, so far as I am aware, was any sound-wave heard, indeed I have only once heard this: some years ago at Murree, when an east and west shock occurred (at about 10 o'clock P. M.) in the silence of the night. I find, however, that a noise was heard in some cases accompanying the shock of March 2nd, 1878, though entirely unnoticed in others, and positively absent at Ráwalpindi, according to a careful observer.

The detailed information, such as it is, which I have been able to collect with regard to this severely-felt earthquake is as follows:—

Earthquake of March 2nd, 1878.

Bannú. The shock was felt here severely and lasted unusually long. This is all the information I can gather.

Kohát. Captain Plowden, Deputy Commissioner of Kohát, replying to a letter, informs me that the shock occurred there at 39 minutes past 11 o'clock A. M., station time, or noon? by Madras. The motion came from the west with a rumbling sound like that of the underground railway-trains, followed by a roll and three sharp shocks: no shocks were observed before or after this earthquake and its duration was not accurately determined.

Major Ross, 1st Sikhs, who gave this information, was bathing at the time, and says the water was driven out of his tub to the height of eight inches or so, and the bath-room seemed to heave like the cabin of a ship at sea.

* All local, not Madras time, for which add 23 minutes.

Several houses and public buildings in the district were cracked and otherwise damaged.

I am informed by another Officer (Major Browne) who was then in Kohát that he felt the shock at about the same time given above, it lasted some two minutes, shook the whole place very violently, so that people left their houses, and it seemed to come from the westward.

A considerable portion of one of the walls of the strongly built Fort of Kohát was thrown down. No accompanying sound was noticed by my friend, and the whole character of the disturbance seems to have resembled that of other places.

Pesháwar. My informant felt the shock here as he was "marching out" with his regiment towards Jamrúd. It occurred at noon nearly, Madras time, (or after 11:30 station time) and he was then about three miles from Pesháwar on the Jamrúd road. A halt having been made, some of the men who were sitting down jumped up, startled by the motion. He noticed that a low rumbling sound immediately preceded the shock: the earth was plainly seen to undulate, and a water-cut beside the road, after the shock had passed, showed a lately wetted margin of two feet or more, consequent upon the transit of a longitudinal wave caused by the undulations. The motion came from the westward in the direction of Jamrúd. Some of the people present felt nausea.

On his return to the station he found the front of his bungalow thrown down. A wall of the fort also fell, and several other houses were damaged. The Barracks escaped, owing to their having been built with iron couplings in the walls, and in the city, from the use of wooden tie-beams in the masonry, because of the damage often done here by slighter earthquakes, the injury done was less than in the Station.

Naoshera. Reports say the shock was severely felt here.

Hoti Mardán. I can only learn that the earthquake-wave here set things which were suspended swinging in an east and west direction.

Attock. At Attock the earthquake occurred late in the forenoon (station time) about noon by Madras. A wall of the Serai or fort was thrown down, and the motion of the earth was strongly felt even by people on foot, by whom a strong shock may often pass unnoticed.

Abbottabad. Here the movement commenced within a minute or so before or after 12, noon, (Madras time) as nearly as I could estimate from the time usually kept at the station. I was lying sick in bed but happened to have my watch in view; there was a palpable undulation crossing my bed from westward to east. At first it commenced with a slight tremor of the usual kind and after a short pause of perhaps 3 seconds, this returned with greatly increased strength. The wall of the room cracked from the crown of the arch over the door to the roof, which being of wooden shingles

creaked and strained so loudly, that I may have been unable to notice any sound-wave. I got up but could only move slowly, and after some delay in securing my watch by which I was noting the time, I reached the outside of the house, and heard the crash of chimneys falling at the neighbouring bungalows, while the stones of the one belonging to the dâk bungalow I had been in, were all shaken asunder, though the chimney (a low one) did not fall. A cup half filled with milk in my room had its contents violently thrown out, and projected nearly to the distance of a foot on each side towards the east and west.

During the shock the vibration was so continuous or so quickly repeated as to seem without intermission after the first one I have mentioned, and the motion died away more gradually than it commenced. I timed its duration as 1 minute and 50 seconds from first to last.

Doctor Grant, then acting Medical Officer of the station, who had left me shortly before, was walking up an inclined open space when the shock occurred; he observed the ground to undulate and the trees to sway about considerably, though there was no wind, he felt a sensation of nausea and found it difficult to walk. Next he saw a man thrown from a ladder and then a cloud of dust rising from the falling wall of a bungalow. On reaching his own he found the wall cracked, also above an arch.

Some time afterwards I was staying at another two-storied house in this station which had suffered very much. Some of the walls were cracked from near the ground to the roof; the cracks passing through weak places, such as openings for windows or doors. I noticed that it was in most cases those walls which ran east and west that were cracked; as if a short wave to which they could not conform had passed longitudinally beneath them.

No one in the place remembered an earthquake of such severity to have occurred before.

Râwalpindi. At this station the earthquake occurred immediately after gun-fire (12, noon, Madras time), possibly a little later than at Abbottabad, but the time kept there is scarcely to be relied upon to a minute. The movement appeared to come from a direction north of west, to judge from the observations of Dr. Henderson, and from the directions in which he found water to have been thrown out of vessels. It lasted for over a minute. Dr. Henderson is certain there was no sound-wave, but another person stated that a low rumbling sound did precede the shock.

Dr. Henderson felt the heaving of the earth very distinctly; his little boy fell down and asked what was the matter with the ground.

Dr. C— of the 10th Hussars was talking to the Mess Sergeant in the compound of the Mess, he did not recognise the occurrence as an earthquake, but felt sick and walked to a tree for support. On returning a minute or two afterwards, the Sergeant said he too had felt sick, and asked for medicine.

Some of the houses in the station were rent and shaken, and a forge at one of the workshops was thrown down, but the damage done seems to have been less than elsewhere. The place is situated on an open plain and stands upon a considerable depth of sandy and coherent brick clay, overlying highly inclined sandstones and clays, often vertically bedded.

Jhelum. The shock was felt at Jhelum at noon, Madras time. It appeared to come from N. E. and to pass to S. W., and it was unaccompanied by any rumbling sound. It damaged the steeple of the Church near the top, cracking it across and shifting the upper part both by lifting it to one side and turning it horizontally on the base of the broken part, as far as can be seen from below.

The Officer who communicated this thought he must have got a sun-stroke; he was out of doors when the shock occurred and the ground moved, and he noticed an interval after the first, between it and the (?) stronger shock which followed, much in the same way as occurred at Abbottabad.

Murree. In a letter from Murree it was mentioned that the shock was severely felt, and house-property sustained considerable damage: no further details have reached me.

By another letter (from Mr. Holman) I learn that the time the shock occurred was 12 o'clock, noon: its direction so far as he could remember was from south to north.* (From another observer I learn that the direction appeared to be from west or west by south.) Its duration he supposes was about half a minute, though most people said three minutes. (N. B. The average of these would give one minute and three quarters, very nearly the time observed of Abbottabad.)

There were three distinct shocks, the last the most severe, and he only remembers one as bad during a long-continued residence of many years in Murree.

Some damage was done to the station, walls fell, and several chimneys also. One observer heard two distinct loud sounds like volley-firing, which he attributed to the working of the shingle roofs.

Lahore. My information concerning the earthquake at Lahore comes partly from the "Pioneer"—or the local press (Civil and Military Gazette), partly from a friend who was kind enough to make enquiry for me.

From the report in the "Pioneer" of March 6th, 1878, though the shock is said to have been severe, the writer did not himself notice the occurrence at all, but was told of it afterwards, and gives the time as *noon*, presumably Madras time.

In the local paper of March 4th, the time of the shock is given as 4 minutes to 12 o'clock noon. "A continuous vibration of the ground lasted

* The ridge on which Murree stands at an elevation of over 7000 feet runs nearly N. E.—S. W.

for 3 minutes," and the earth "wave appeared to travel from east to west."

One of the gentlemen who wrote to my friend, says, he was sleeping at the time, and being suddenly awakened by the earthquake, he ran into his bathroom to observe the tub. In this, the water was oscillating and had wetted its sides 5 inches vertically above the level shown when at rest. Hanging plants and a bird cage in the verandah set in motion by the earth-wave swung to the north and south, a direction corresponding to that marked by the water in the tub.

As to duration the same observer thinks the time given in the local paper excessive, and that it could not have been many seconds, perhaps 30. He does not state that any sound-wave was heard.

A wall in his house was cracked and the filling of an archway showed a complete separation all round the arch. In the city many old houses fell and one in falling was reported to have killed three men.

Mr. Scott, R. E. of Jhelum, heard from Lahore that two friends playing at billiards in the latter station observed a N. E.—S. W. oscillation in the lamp-frame above the table, on the occurrence of the shock, which took place at noon, the same time as in Jhelum.

Ferozpur. Although at Lahore the earthquake passed unnoticed by at least one person, in a station so near as Ferozpur, according to a correspondent of the "Pioneer," something like a panic occurred. He writes—"The first shock was quite violent enough to cause a very sensible movement on the earth's surface, and the dull rumbling noise was so unusually loud as to attract general attention. Half a minute after came the second shock, a very rude one indeed, making floors upheave, walls oscillate, and beams and rafters start and crack. Every one rushed into the open air only to find the ground shivering under their feet. The third shock was gentler, the tremor of the earth, however, continued for a long time, and it was fully five minutes if not more from the beginning of the first shock till the last trembling passed away. No buildings fell, but many beams were started, and some walls were cracked."

The time of the first shock is not given.

Simla. If Madras time is kept at this station, as seems probable, the shock was felt there at the same general time as elsewhere, *i. e.*, one minute past 12, noon. See "Pioneer" March 6th, 1878. The reports in this paper say, the earthquake shook Simla to its foundations, and was one of the longest continued ever known there. "The wave or movement came first from east by south and lasted for about a minute, when it shifted to north-east, and increased in intensity from a tremor to a roll, the shocks occurring without intermission for nine full minutes, the last being at ten minutes past noon. It was the third shock within six months, each being severe."

The coincidence apparent as to time would seem to identify the shocks

here as part of the same earthquake felt in the other places mentioned, but the directions and duration are so very different as to suggest that the undulation, if generated near a line reaching from the Simla portion of the Himalaya, towards and beyond Pesháwar, met with some resistance or disturbing force by which it was deflected or even reflected, and its effects rendered cumulative, so that the shock was felt for a greatly longer period.

Masúrí. An earthquake shock at Masúrí is so mentioned in the "Pioneer" as to render it presumably that of March 2nd, and as a result it is stated that springs had ceased to flow.

The following table of the directions from which the shock was felt to come at different places may be useful.

Kohát,	}	From the west.
Pesháwar,		
Hoti Mardán,		
Abbottabad,		
Murree,		From the south ?
Ráwalpindi,		From west by north.
Lahore,		Uncertain.
Simla,		From south of east and north-east.

It will be seen from these brief notes that the effects of the shock of March 2nd were more or less forcibly felt over the whole of the Upper Punjab and neighbouring regions. The space being so large, the most favourable conditions for observing earthquake phenomena—*i. e.*, constant homogeneity and elasticity of the rocks forming the earth's crust—could scarcely have been expected. Mountain regions being exceptionally unfavourable from the form of the ground and liability to variety of formations, fissures, planes of displacement &c., much disturbance of the earth-wave, and variation of effect might have been anticipated; and yet it would appear that the shock must have been almost simultaneously felt along the whole western outer Himalayas and their continuation, from Masúrí to Pesháwar, in a direct line some 455 miles apart.

Assuming 30 miles a minute to be a high rate for transmission of an earthquake wave (Mallet, Admiralty Manual of Scientific Enquiry) and that this shock originated near either Pesháwar or Masúrí the passage of the wave from one station to the other would have occupied about 15 minutes, and it should have been observed so much later at one of these places, which would perhaps be a large error to attribute to the time recorded. But if the shock started from a point near midway between and occupied half the time in reaching these points almost simultaneously, then a smaller error of time would be both possible and difficult to detect from the records at hand. There is, however, no information available regarding the earthquake from the vicinity of Kishtwár, which would be about half

way in the Himalayas, though at Lahore, nearly in the same relative situation, on the plains, the time given is “*about noon*” according to observations made, or the same as at either extremity of the region known to have been disturbed.

However these considerations might indicate a seismic centre among the mountains somewhere on the Simla side of Kashmir, the observed motion of the undulations both at Simla and towards Pesháwar are against the supposition of such an origin, even though a considerable amount of this motion be attributed to secondary vibrations masking the main earth wave.

If the disturbance had one common source, and if the *primary* undulation reached the earth’s surface at almost the same time at all the widely distributed points indicated, it may perhaps be a legitimate deduction that the place from which it originated was very deep-seated, or else that the conditions of the earthquake were somewhat peculiar and the disturbances were initiated along an extended line rather than at any particular point.

It will be noticed that the greatest differences in the results, so far as the information collected extends, took place at Simla, Lahore, and Ferozpur; differences both in the duration and direction of the motion* which would render further information most desirable, and it will be observed that this disparity coincides in a way with the marked general change in the alignment of the mountain ranges. All the stations close to the outer Himalaya in the upper Punjab, whence I have obtained any details, stand among or adjacent to ranges belonging to the east-west, or west-by-south system, prevailing on the Pesháwar side of the Jhelum valley, while Simla and Masúri are upon or near ranges having the north-westerly bearing common to the main direction of the western Himalayan chains. On the supposition that the earth-wave travelled from the west as indicated by so many of the upper Punjab observations, it would have passed longitudinally amongst the western mountains and under the adjacent Ráwalpindi plateau towards the east as far as the Jhelum valley sinus, and, meeting the oblique ranges beyond, might have manifested itself in a different manner.

The varying geological structure of the whole region does not appear to have appreciably influenced the results of the earthquake’s manifestation at different places. Pesháwar stands in an alluvial plain; Attock close to the edge of the Indus flats (at their junction with, but more correctly,) upon a mass of slates. Abbottabad is close to, if not actually traversed by, a long line of fault having a very large (unestimated) displacement and

* In the case of Murree my informant seems rather uncertain, as to the direction, but my Lahore information is positive as to this being N. and S. though from which is not stated.

cutting off limestone mountains from others formed of slate. Ráwalpindi is on a plateau formed of tertiary rocks, alternating sandstones and clays, just there nearly vertical and horizontally overlaid by post-tertiary and perhaps even newer clays, sands, and boulder-beds. Lahore and Ferozpur are on the alluvial Punjab plains.

In most of these places, the shock occurred at the same time, as nearly as can be judged, and its results were similar, whether it lasted under two or as much as five minutes.

Kohát, close to east and west ridges of limestone or of sandstone, and standing upon a stony detrital deposit at the mouth of the Hangú valley, is about 80 miles due west of Ráwalpindi: in both places the undulation approached from the westward, in the latter more nearly west-north-west.

Simla is entirely differently situated from these stations; at a great elevation and nearer to crystalline masses which would probably afford a better conducting medium for the earth-waves. Yet here the time of the occurrence was presumably the same as elsewhere, and though the movement is said to have come from opposite directions and to have lasted fully nine minutes, I have no evidence that the damage caused, which would be a measure of the force exerted, was at all greater than at Abbottabad or other localities.

I have heard it more than once observed that these Punjab earthquakes usually occur after rain has succeeded a spell of fine weather; indeed Dr. Henderson tells me that from this he predicted the occurrence of the earthquake previous to that of March 2nd, felt at Ráwalpindi as well as by myself in Hazára. With reference to this point it should be remembered that the nine distinct shocks which I have mentioned as having recently occurred in the Punjab within fifty-three days, have followed a season of excessive rainfall preceded by an exceptionally and disastrously dry summer.

Whether the access of meteoric water by gravitation through the rocks to hotter regions below be a sufficient cause in the present case for the phenomena observed, or a better one can be suggested, I must leave for the enlightened consideration of competent seismologists; and though several minor shocks are not unusual attendants upon a greater earthquake, I venture to suggest that something exceptional in the way of cause must have occurred to account for the greatly increased frequency of late of the earthquakes in the Punjab, where they have rarely taken place more than once in a twelvemonth, at least for the last nine years: and also for the greater than usual intensity which has marked one of them, almost simultaneously felt over an area, which may be roughly estimated at 67,000 square miles.